# Space Weather Technical Forecast

Issued on Friday, 22 September 2023 at 13:31 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Isolated R1-R2 Minor/Moderate Radio Blackouts likely throughout. Risk of G1 minor geomagnetic storms through the next four days, especially on 23 and 25 Sep.**

**Analysis of Space Weather Activity over past 24 hours**
**Solar Activity:** There are 13 sunspot regions on the visible disc. Solar activity has been Moderate over the last 24 hours, with a M8.7 at 21/1254 UTC from AR3435. This is the largest region on the visible disc and is the most visually and magnetically complex region. AR3443 has developed rapidly in the last 24 hours and is now exhibiting a delta spot as the region continues to evolve. AR3442 was originally classified as a large region, but this has been divided into two, with the larger portion of this region showing rapid development. All remaining regions are either stable or are only evolving slowly.

A faint CME from the M8.7 eruption has been analysed as having a possible earth directed component. A further eruption from north-centre disc early on 22 Sep will be analysed as further data becomes available.

**Solar Wind / Geomagnetic Activity:** Solar winds, as measured at L1, steadily declined from 450 km/s to around 400km/s. Density has been around or slightly below average. Interplanetary magnetic field strength was weak throughout, with the north-south component also varying weakly. Phi angle was indeterminate, with frequent rotations in the magnetic field direction. Resultant Geomagnetic activity was Quiet to Unsettled.

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux was at background levels. GOES16 high energy (greater than 2MeV) electron flux was generally at moderate levels, but rose to High between 21/1640 UTC and 21/1900 UTC, with a peak of 1420 pfu at 21/1740 UTC. Associated 24-hour fluence was below the Active (1e8 integrated pfu) threshold, with a steady decreasing trend to 2.75e7 integrated pfu observed at 22/0001UTC.

**Four-Day Space Weather Forecast Summary**
**Solar Activity:** Solar activity is forecast to be at mainly Low to Moderate levels. The main risk of M-class flares is from AR3435 and from developing region AR3443 in the northwest. These regions contain delta spots and are the main source of a risk of X-class flaring.

**Solar Wind / Geomagnetic Activity:** CME arrivals are possible through much of the period, with the highest likelihood on 23 and 25 Sep. High speed streams from coronal holes 51 and 50 could connect with the Earth on 22 Sep. The effects of coronal hole 51 could wane by the end of 23 Sep, but the high speed stream from large coronal hole 50 could affect Earth throughout the period. Mainly Quiet geomagnetic activity at first, but with a risk of Unsettled to Active through much of the period and a risk of G1 minor storms, mainly on 23 and 25 Sep.

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**Energetic Particles / Solar Radiation:** High energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily slight chance of an enhancement should any larger flares occur especially from AR3443. High energy (greater than 2 MeV) electron flux is likely to become suppressed before possibly rising towards high levels again later in the forecast period. The 24-hour fluence is likely to remain below the (1e8 integrated pfu) Active threshold throughout the period, but with a rising trend possible towards 25 Sep.

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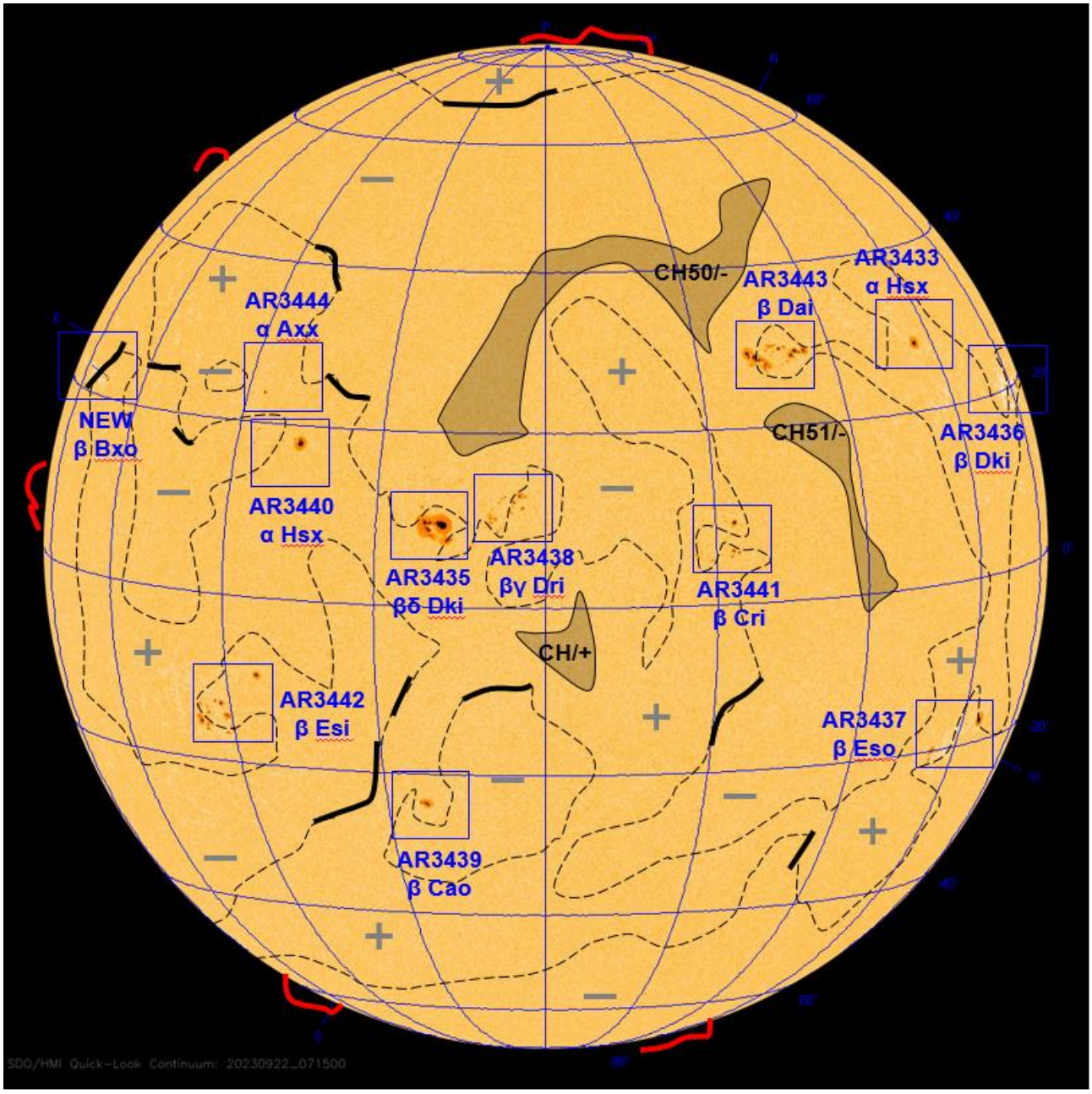
**Figure 1. Solar Analysis Valid 22/0800UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

A CME which left the Sun on 19 Sep is forecast to glance Earth either late in 22 Sep, or more likely during 23 Sep. A further CME from 20 Sep, is then likely also likely to glance Earth on 23 or 24 Sep, but with low confidence in timing. A further CME following a M8.7 flare on 21 Sep may arrive at Earth late on 24 or during 25 Sep, but again with low confidence due to difficulties in achieving an accurate fit.

The near-Earth environment is generally benign, following recent CME arrivals. Coronal hole 51 is then due to connect with Earth late on 22 Sep, with speeds estimated to be between 500-600km/s possible, but with a contribution also possible from coronal hole 50, which is large developing feature. Both these coronal holes are negative polarity, so is unlikely to connect favourably with the Earth's magnetic field as we are close to the September equinox. Solar winds from coronal hole 50 are then likely to exert an increasing influence on the Earth through 24 and 25 Sep.

Mainly Quiet conditions at first on 22 Sep, but with an increasing risk of Unsettled to Active intervals on 22 to 23 Sep due to any combination of CME and weak coronal hole effects. Similar effects are possible through the period, due to the potential combination of coronal hole high speed streams and potential CME arrivals for many of the days.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 20 | 30 | 20 | 30 |
| Strong | G3 | No | 1 | 5 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 20/0315 | Partial | Flare | AR3435 | 515 km/s | 22/23 Sep | Slight glance possible |
| 20/2051 | Partial | Flare | AR3435 | 560 | 23/1700 +/- 9 hours | Moderate confidence. |
| 21/2042 | Partial | Flare | AR3435 | 470 | 25/0400 | Slight glance possible |

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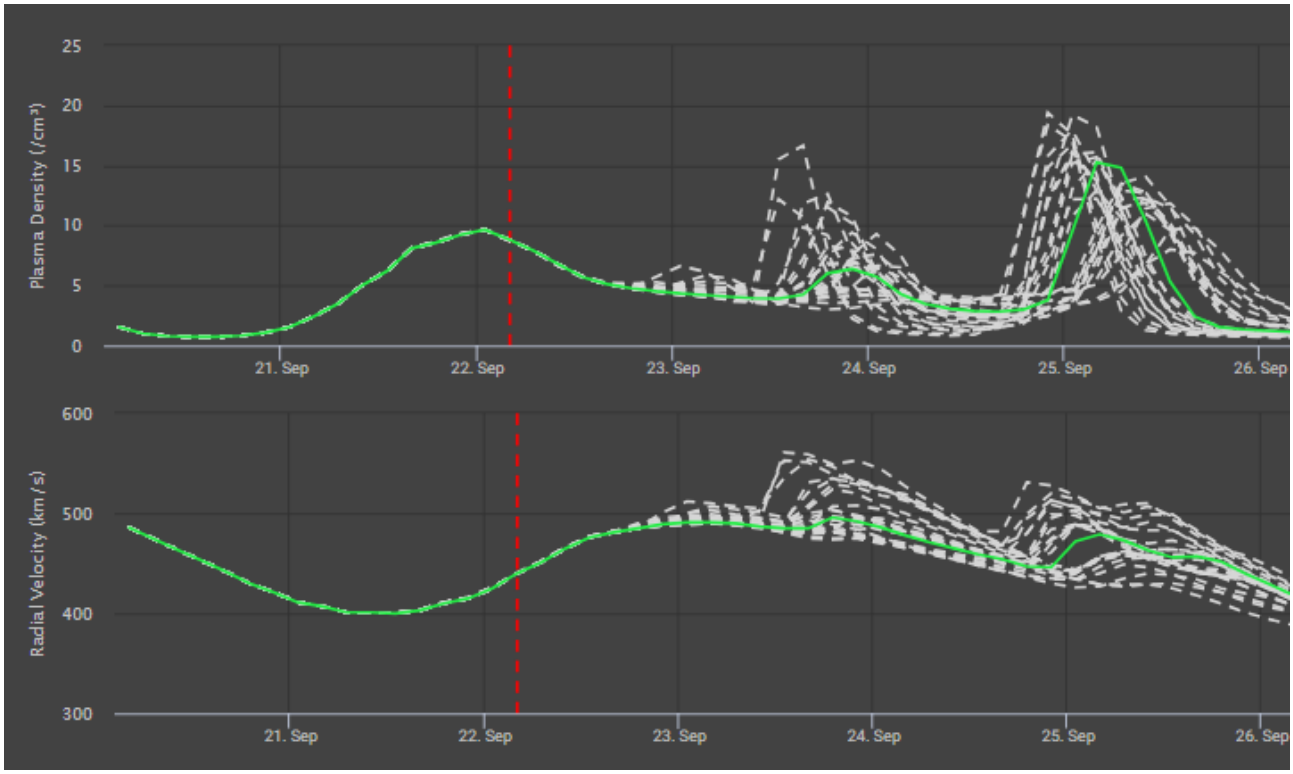
**Figure 2: MOSWOC Enlil ensemble forecast, which demonstrate the most likely arrival times of the CMEs.**

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## Radio Blackouts - X-Ray Flares:

There are 13 numbered regions on the disc, with 11 of these numbered. The largest and most active region is AR3435 in the northeast central disc, which has a history of M8 flare activity and is both visually and magnetically complex, with a delta region. AR3443 in the northwest is developing rapidly and has developed a delta spot. AR3442 in the southeast is varying in complexity and has been re-classifed as two separate regions. This spot continues to be monitored. The remaining regions appear simple or are only evolving slowly.

Solar activity is expected to be at mainly Low to Moderate levels, with a chance of M-class flares and a slight chance of X-class activity, especially from AR3435 and the now-numbered region close to AR3442.

| X Ray Flares / Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **R1-R2 M Class** | Yes | 60 | 60 | 60 | 60 |
| **Very Active** | **R3 to R5 X Class** | No | 10 | 10 | 10 | 10 |

## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at background levels, but with a daily slight chance of flux levels rising in response to any significant flaring. The main current risk of from AR3443, which has developed a delta spot and is in the northwest quadrant.

| Radiation Storms / Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 10 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

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**High Energy Electrons Event (≥ 2MeV):**
High energy electron flux (greater than 2MeV) have been varying between moderate and high levels on a slowly oscillating cycle. The levels are likely to be initially suppressed through the next 24 hours due to the increasing geomagnetic activity from a mixture of coronal hole high speed streams and possible CME arrivals. These are likely to produce competing effects with the input of electrons into the radiation belts contrasting with the geomagnetic activity redistributing the electrons and possibly reducing radiation populations. Although the speeds are forecast to be relatively modest, there could be some distortion of the belts with GOES 16 leaving the radiation belt environment for a short period. Given the low confidence in the CME forecasts, there is high uncertainty in the possibility and timing of any drops in electron flux.

Electron fluence, based on the uncertainties in the detail, may trend towards the Active (1e8 integrated pfu) threshold through the period given the large amount of solar radiation forecast to be input into the radiation belts.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 10 | 10 | 20 | 30 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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